PHYTOCHEMISTRY AND PLANT/ANIMAL INTERACTIONS RELEVANT TO FREE-RANGING BLACK RHINOCEROS

Raoul du Toit

TAPE 5B 619

du Toit: I am not going to make a fool of myself by spending much time talking about the physiological aspects of these interactions between plant defending chemicals and then browses. There are a number of people in the room are far more qualified to talk about that, so I will really adapt more of an ecological perspective. I am sure there will be some valuable ongoing discussion from those people who are in a position to contribute more on the *theological* aspects of this. If we look at our black rhino habitats in Africa, the savanna systems, we have got a lot of vegetation in those areas, but that vegetation is largely unutilized by anything. Of the folage that is produced in the savanna communities, maybe 5% is eaten by insects, and I would guess 622 that seems to be coming up in terms of the portion that is gobbled up by mammalian herbivores is only about 5%. The rest of the leaf material falls as litter and then decomposes. So there is a very low utilization of that vegetation. This means that in fact, the production of browse 629 ungulates 630 savanna systems.

We have got two main savanna systems in a simplistic breakdown. If we look at the savanna systems in Africa, we have got two main categories. We have got what we call the arid eutrophic savanna areas, which are the dry areas with high nutrient *sediment* soils; compared to the areas of high rainfall of over 700 mm seems to be a *cut off point*. Areas on granitic basements of rocks with porous nutrient *sediment* soils developing in those areas, leaching, more leaching of those soils in the high rainfall. And we have got very different plant communities in those different savanna areas.

In the arid eutrophic areas we have got a very fertile situation and a rich browse resource compared to dystrophic low nutrient status areas with high rainfall, where we have got what we call predominately the 651 community, a community in which there is a lot of good vegetation, but it is of low quality for browsing animals. We come into *three separate constraints* in terms of black rhino management in these different systems. We have had some 656. This is the typical situation in a low veldt in an arid eutrophic kind of environment. There is considerable seasonal variation in the browse resource. But throughout the year animals like browses that range over the whole landscape. They can find the browse resources along the river lines. Along the river lines you have got quality browses throughout the year.

With these rocky areas... This is one of our conservancies where we have been moving rhinos, an area of 1300 sq. kilometers in southern Zimbabwe. We have now got 38 black rhinos in there that have done very well. One of the features of this area is the granite outcrops between the more fertile valley areas, which are composed of a 672 geology. There is a lot of run-off off these granite outcrops leading to local more humid areas around the bases that supply a good diversity of browsing species for rhinos. The key

really is that when you have got terrain diversity, you have got vegetation diversity. Rhinos really depend upon that vegetation diversity.

We have got some fertile alluvial areas, the large rivers that visit the 683 Conservancy of 3200 sq. kilometers, for those who work in acres it is 850,000 acres, in which we now have 35 black rhino all doing extremely well with good reproduction. Here we have got an extensive alluvial fan community. It is interesting in fact that the phosphorous 689 resource here is particularly high because there is this upstream *alkaline* 691 geological complex that releases phosphorus. In fact there is 692 mines that supply Zimbabwe's phosphorous fertilizers, and these alluvial fans here completely high phosphorous level 694 black rhinos.

The rhinos in that part of the world are in very good condition, you can see the thick bulging neck on this bull. This is an animal actually re-caught. We caught him a couple of months previously and we held him in a boma for a while. He had broken out through a number of fences, we re-caught him. So even though he had been through a fairly tough sort of period and done a hell of a lot of walking, he was still in pretty good neck. Last year we had the worst draught on record. Down in these *low veldt* areas there was absolutely no grass resource whatsoever. These are white rhinos that had to be supplemented at feeding stations through a provision of green maize produced through irrigation at a few sites. So there was a massive feeding program through this area just to keep the grass animals and *to feed them grain.* All we had to do to the black rhinos was to insure they had water in a couple of sites. Even that was not essential. What we were concerned about was breaking up an established social structure, because the rhinos had sorted themselves out around the water points and we had some really nice rhino grouping that we were monitoring and seemed to be breeding well. We were concerned that as the water holes dried up, the animals would redistribute and then we would lose an established social situation. So we supplied water to make sure that those water points were supplied with browse to keep the rhinos in, and they stayed there. But apart from that the black rhinos fended for themselves. This is not a good photograph, but that area was just unbelievable in terms of the aridness, the total absence of anything green whatsoever for the rhino to eat. Yet, when we undertook dehorning operations in these areas at the end of the drought period in December of last year, the conditions of these animals averaged 4.5 out of 5. They were in extremely good condition and that is obviously a testament to the high nutritious quality of this vegetation, given the drought situation.

Now that is of course that arid eutrophic system contrasted with the dystrophic and low nutrient status beyond the savanna communities that extend through some parts of Africa. In these areas we have woodland dominated by two genera 734 and these are very unproductive for browsing animals. Sandy *prolific* soils with low nutrient status *leeched acidic*. As you can see in that photograph, the fact is there is not that much vegetation within browsing range of rhinos, and what is there is very heavily defended. Because the point of all this is that there is a strong relationship between the soil nutrient status and the extent to which plants defend themselves against browsing pressure. In an arid eutrophic situation where

there is good soil nutrients, plants can afford to get themselves chomped up by animals, and then they can regenerate. In an area like the ***midlands here though***, because there is relatively lower soil nutrient status and because of the very much colder 750 temperatures 751 this area, plant growth is constrained, and plants therefore have to find some way of defending themselves against getting chomped up by browsing animals. They invest much more heavily on chemical defenses and this is a consistent pattern throughout the world where browsing 757 there is much greater investment in chemical defenses on the part of plants that are growing in poor nutrient sites, low nutrient status sites. We have seen problems in this area.

A number of black rhinos where moved in there. What we first started seeing there... In the monitoring of animals we were not picking up condition losses in any great way. We had animal mortalities, but at that stage we tended to scribe them to the convenient "translocation stress" which was a term thrown around quite a lot by the land owners and the management that was involved in some. We started seeing that as this devastation 771 of termite mounds. The vegetation around these areas sort of absolutely had it. What has become clear over time as we propose to look at the situation in more detail, is that these are nutrient hot spots. There is an accumulation of nutrients there with much better quality browse. And if one goes through these areas you find that good browse species are concentrated around 778. And really what it boils down to is that the termites *are feeding* 779. And there are some very interesting implications where ecosystem nutrient cycles are a consequence of the fact that these rhinos, by being confined in 781 by devastating this vegetation to beyond the point of regeneration. In fact damaging 784 while affecting ecosystem nutrient cycles 784.

A number of mortalities as we have gone on, in fact, we have documented at least eight deaths in this area to just straight poor malnutrition, the animals just starved. I mentioned last night there has also been a few just fighting between animals in the dry season, even between females. There has been a lot of condition loss. This was an animal that died a year after translocation. It lost a lot of condition. We had this pattern of dry season mortalities occurring which started really getting us worrying about the situation. Now black rhinos have *not* lived in this area historically. There were a number, but it is quite clear that in the past they were able to move in accordance with there browse resource and they were able to get to areas where they did not have to contend with this poor quality and heavily chemically defended large browse resource.

This was typical of the captures we undertook in this area earlier this year. We had a hell of a fight with the land owners. It was quite a *mission* 811 operation, actually going in there with helicopter gun ships rather than helicopter 812. There was a lot of opposition from the land owners who refuse to accept our management recommendations on these animals, we eventually just went in there removed them. Whereas we had this very good condition of the animals in the *low veldt* areas after the drought. In this area the average condition of the animals was probably 3.4 out of 5. And that is in May/June, after the vegetation growing season Our main rains start falling in December and so vegetation grows through then.

In the low veldt we have been immobilizing animals before the main growing season. Here we are after the main growing season, yet the condition is only 3.4 out of 5.

Munson: Just to confirm what you said before, these are not the ones you saw the ulcers in, these poor conditioned animals?

END OF TAPE 5B BEGIN TAPE 6A

du Toit: No, but we did see... I can not remember who we saw ulcers in. We have never seen ulcers in free-ranging rhinos, it was in the boma confinement situation.

Munson: So even though they are starving to death, you are not seeing any ulceration?

du Toit: No.

R. Kock: How many animals 003 the low score animals?

du Toit: That was an average 3.4 out of 5 for all the rhinos immobilized in that area. What was interesting 005 we did a total of 45 rhinos 005 the area. The average of those 45 was 3.8 out of 5. This area was a single area 007 showed some interesting patterns among the rhinos. The big bulls were in fairly good condition. The one was 4.5. A couple of bulls were in reasonable condition. The ones in worst condition were the subadults like this guy. What was obviously happening was the big bulls were excluding the small animals. They had been separated from their mothers and suffering from the stress of being pushed away. The big bulls were excluding them from the prime habitat. They were pushed off into these areas of very marshy 012 woodland, and just not fending out for themselves. We moved that animal, in fact we tried to do our best, he would have definitely died if we kept him there. We moved him out of the 014 kept him in the bomas for a couple of months and brought cubes, the only supplementation really we could do. He did not pick up condition. We had an unseasonable cold snap, with two inches of rain. He was shivering to the bones and not doing well at all. He had been through a previous period where he had got depressed and went off his food and because of everything that we talked about earlier, we decided the only thing was to release him. It was possibly a mistake, but I can not follow the judgment of the landowners. The boma was wet and muddy and so we released him and he died a couple of days later in the worst condition, extremely thin.

So looking at the browse resources, we have got a problem here. It is not only us in Zimbabwe, a similar embarrassing situation occurred in South Africa recently. The 022 had been selling rhinos, auctioning rhinos. One landowner paid a quarter of a million 023, or 30,000 US dollars for a poor rhino. He bought eleven rhinos, moved them to his 025 up on one of these dystrophic savanna systems. Five out of those 11 rhinos have died through straight forward malnutrition. *So there has been a panic* about this issue of moving animals.

What we have to consider when we are looking at the browse resources for an animal like the rhino, is the proportion of the vegetation that is accessible, that is edible and is acceptable to the rhino. These plants obviously are investing in defenses and they have got two main forms of defense, the chemical

defenses, and the physical defenses in the form mainly of spines and thorns. What we see is that in the arid *low veldt* eutrophic areas plants invest more in physical defenses. You get fine leafed spinescent species like acacia which *exclude rhino browsing on them* compared to these dystrophic 034 areas where there is a fair better condition of chemical defenses. As a rule of thumb, there seems to be a good relationship between this question of palatability and the degree of physical defense. 036*.

Obviously, there is not just tannins, but there is a whole range of secondary chemicals: 038 compounds, alkaloids, 039 and so on. These are highly specific activities and I think something that people are coming to learn as they look at this question of browse interaction, is that they know in the *central megasystem play* there is a hell of a lot of variability in what goes on in terms of the type of chemicals that are being produced by plants and the response of the animals to those chemicals.

In terms of the tannins, people have looked at them in two main ways, as digestion inhibitors in terms of tannins binding the protein, or as toxins, as Evan [Blumer] pointed out earlier and high 044 of tannins to breakdown 045. There seems to be increasing evidence that it is not the condensed tannins *really that is the big issue* with browses, it is the high 046 tannins. It is not inhibition of digestion that is the problem, it is rather the direct toxic effects of some of these chemicals.

There is considerable variation in the types of chemicals that are produced in any particular plant, according to the growth phase of the plant, according to the part of the plant, even according to whether it is night or day, as we spoke about earlier. There is a big variation in palatability, there is a big variation in the manner in which animals browse on plants 051 their *lunar* cycle, according to what the plants are doing in terms of secondary chemicals they are producing.

What actually happens with these animals when they eat these things? It seems that there is obviously a sort of feedback mechanism happening in an animal when he eats a plant. There is some sort of post digestion consequences that arise. Because the biggest consequence that 056 feedback that results in that animal *not eating at that plant*. And there are obviously very complicated processes that boil down to learning. You know, we talk about things agreeing with us and not agreeing with us. There are some of the things that one person can handle and others can not. I can not handle any tea. Some of my colleagues in Zimbabwe have worked for the government for years and years and they can not operate with out it! There is obviously quite a variation. The other thing is if you consider some of the things that have poisoned us in the past, how we have learned just from one occasion. I think maybe some of us have been drunk a few 062 in the past, and just one smell of that and you do not touch it again. Obviously there are things like that going on in these rhinos, they learn.

And when you consider rhinos, which are a large browser, trying to move around 064 landscape. It is a long-lived animal, it has got to go through a hell of a lot of seasons with different climatic conditions, particularly rainfall. It is going to have to be reactive to a vast range of browsing opportunities. The only way it is going to determine what is right and what is wrong is through the process of adaptive management. So these learning mechanisms are important. There is good evidence that browsers learn a hell of a lot

better than others. A lot of the response to browse resources is a learned response that is taught extremely early. There is evidence to show that animals keep this since they have been raised in one part of the 071 and moved to *the valley* just a few kilometers away really do not cope terribly well because they have not learned how much they should eat of different plants. It really boils down to this, there is a threshold of tolerance levels. An animal can eat a certain amount of something and then no more, it has got to go on and eat something else. And that I am sure is the key to why rhinos need such lengthy browse resources. You simply can not restrict them *you will probably make some of them* 074. And that had been a big mistake in the past in terms of boma management in Zimbabwe.

If you looked at the few plants that they really seemed 076. We have got a form of euphorbia or rubber tree producing a thick looking latex. I am sure it is full of 078 and that sort of thing. It is very much like some of the Namibian euphorbias that maintain populations in pretty arid areas. People have seen them 079 and when they move a rhino held in the boma, they say, look at that rhinos love rubber trees. They are nothing but rubber trees. People were wondering why they eat them, because they usually do not touch them. There is a big problem *with us releasing these animals* 082 browse resources limited.

The high 083 tannins that is known that in animal in browse they can cause very severe necrosis and ulceration of the epithelium of the esophagus, of the stomach, intestines, and so on. The various, Don [Paglia] is probably qualified to talk about this, can get a very good reaction to take place in this interesting issue of the extent to which some of these red cell enzyme systems may be highly linked with negatively, or who knows, it may be positive in some way we have not found yet, with sorting out these *detoxifying* plant chemicals.

One interesting thing is that some of these *phenols*, when conjugated, come out in the urine as a very pink coloration. And we see this in black rhinos quite a lot. It has got a few people very worried in relation to a new problem. They see pink urine, bright bright pink urine. It is really red sometimes, and people panic about *hemolytic anemia*. But it happens a lot in the wild. You often see where male rhinos have been spray marking. If you collect that urine it is very often very brightly colored. And there seems to be a good reason to suspect that maybe just that the phenols have been conjugated.

The question is how can we go about monitoring this kind of thing? It really boils down to this question of carrying capacity and stocking rates and so on. It seems obviously logical to presume that in an area like this 099 area, that as the rhino carrying capacity increases, the animals are forced to resort more and more to eating on plants that they normally would not eat. Although there is good evidence to suggest that animals just simply stop eating after a while, they do not eat a plant to the extent that it poisons them, they just stop eating it, and starve. It seems to happen in a number of animals. But nonetheless, one can expect that there would be increasing exposure of a rhino to plant chemicals as he is forced to browse on lower and lower quality browse through the pressure of other animals in the area. So as one gets 107 one needs to start monitoring the degree to which plants that are normally being avoided, are in fact, being browsed. There again, once we have to take this whole seasonality thing, because rhinos may eat one plant

one time of the year and avoid that plant another time of year. There are all sorts of interesting things that go on. For instance after a fire, a veldt fire, rhinos often eat plants that they normally do not touch. There is a good reason I think to believe that some of the phenols have been *watertized* by the fire. It is just a very interesting fact, that has been observed in a number of areas as these plants 113. Anyway, so it is difficult to really sort these things out.

It is all a question of learning as a constant process. A rhino does not just stop eating everything. It eats a bit of a plant at one time, and tries it again a few months later and so on. So it is difficult to monitor, but I think if one gets to know an area especially well, one will get to know what sort of plant the rhino is eating on, and as carrying capacities increase and as stocking rates get to a higher level, you see a better utilization of other plants.

I would very much like to take it a step further and start analyzing some of the excretory, what is coming out of the rhino. *Bill* 121 was working on the interaction between browsing marsupials in Australia and these plant chemicals, and has come up with a new sort of grand unifying theory. Obviously there is a whole lot of detoxification *maintenances* going on in these animals. But what seems to be the ultimate outcome of most of these mechanisms is acidosis. Whatever goes on they generally lead to an acidosis situation. So if one can somehow take acidosis maybe from urine, plus and be looking at glucuronic acid, but may have to index that according to the 126 reaction, because there would be variation in 127. One could maybe monitor the extent to which rhinos are having to contend with chemical defenses and maybe that is an assistance that will work. There may be a way of verifying the suitability of browse species you may want to offer your rhinos in an exotic habitat, like in zoo situations. What you need to do is offer a rhino a range of browse. I have no doubt that these rhinos here in the United States need browse. You have got to give them browse--but what? Well just give them a few 133.

OK, other ways that rhinos *cope with* these things... A number of browses produce salivary proteins that will bind with tannin. Instead of the tannin binding with the protein in the browses at it is eaten, the salivas bind with the protein instead. The animals 137 the saliva binding with the tannin, salivary protein. So what we see is an interesting trend where very small browsers like dik-dik and duikers have these massive salivary glands compared to grazing animals. They are huge, three times the size. Nobody has looked at the size of the salivary glands in black rhinos, and it would be really nice if somebody got a chance in some of these animals that seem to keel over as regularly as they do, to get the size of the salivary glands. Another interesting possibility is that a large number of ranchers are told that one way they can cope with tannins and *drought* and so on, is to put 145 clays and drink *a little bit* out of it. Now we know black rhinos seem to drink the most horrible drinking water in pans. In our boma management we often take great pride in giving them beautiful clean water. But maybe these rhinos are taking these clays as a means of to trying to cope with some of the acidosis problems they have got.

An interesting thing that came up in Zimbabwe *last week* is the stop of the tradition of using polyethylene glycol as a supplement in the diet of cattle, and other animals that do not eat browse. It is

largely because of the tannins, because polyethylene glycol is a bit like these salivary proteins combining with the tannin 153*. A lot of people were very excited about this in Zimbabwe, my boss and my colleague 154 all over the country for cattle. In fact, in some areas the rhino were sharing the water resources with some of the livestock in these areas. There have been some concerns voiced about whatever polyethylene glycol may do to rhinos. It would be useful to 158 *what do you think.* Is this something that we really need to be worried about? Because there is a lot of pressure from some ranches to use polyethylene glycol in the dry season. I think Mike [Kock] you mentioned that there had been problems in 161.

M Kock: Evan you were the one that began...

Blumer: Yes, I *began to speak against propylene glycol.*

du Toit: Anyway, I do not think it is a big deal. Some people suggested there may be a way to try and get rhinos 163. But as we said before, it is not the digestion inhibition that is the issue. It is the toxic problem of course through *autolyzable* tannins that is really the issue. It is extremely lengthy and involved.

I do not think I have got much more to add on that. It is obviously a fascinating field, and it has got severe management implications in terms of boma management Mike [Kock] mentioned 168. You know there is good reason to consider, even though it is not well proved, that by extracting browse from certain sites we may be causing a problem. Actually what is interesting in terms of the plant response to browsing pressure is that after a certain level the plant will produce more and more *anti-ketones*, chemical defenses. It certainly gets to a stage where it is getting browsed so heavily that it can not do that anymore, it has to invest in *synthetic* tissue. In fact they become highly palatable. What we see in Africa is hot spots of heavy browse utilization, particularly around water holes, and on cattle *properties* and on corners of cattle *properties* where there has been a lot of cattle pressure and a lot of 177. The plants in those areas are highly palatable, because they simply do not have the resources to 178 chemical defense.

Anyway, that is one aspect of management, the question of what you feed the rhino in bomas, how you chop it, where you chop it from. Another thing which is really vital, and in fact has become vital in our Zimbabwe situation, is this question of managing animals from a low point situation up to a high point situation; also particularly in Kenya to some extent. Although in the Kenyan situation because of the fertile *or tannic* soils and lime 182. In Tanzania it is certainly an issue, and in South Africa it is an issue. This question of moving animals from one savanna system to another one, one has to be very careful about. It is not just the adaptation of the gut microflora to the new browse in a different area, but also that the rhino simply do not know that they are not used to those plants. We have done as worst as possible with a lot of these rhinos. We go and catch them in the middle of the year, which is our cool season. Often in the past we have caught them 189* we catch them and move them to a place like the 190 in a real nutritional crunch period of the year, when there is no foliage on the vegetation there. The rhinos are chucked in there, they go straight to the capture boma. They are certainly in unfamiliar country, they have not had their

learning response to know what they can eat and what they can not eat. It is not surprising that we have had very very high mortality, 30% mortality in the 193 compared to a very very low level mortality in *Hwange* only 5% 194*.

R. Kock: A question on other species, things like giraffe, in these areas and the impact they have on the same community as the rhinos.

du Toit: Well, giraffe actually are not a problem, because they feed *other levels* than black rhino.

R. Kock: But if they have got a problem of browse variability, they go down to the same level.

du Toit: The other thing they do is 204 having such big areas that the rhinos and other browsing animals 204 the biomass of the browsing animals is kept well below what 205. It may be a problem in 205.

Blumer: I have a question for anybody in the room about the propylene glycol issue. The injectable ivermectin in horses, isn't it the ethylene glycol that is the problem in that?

Jessup: That is the carrier, that is the problem.

Blumer: Yes, so when Mike [Kock] and I were talking about this in Zimbabwe, I was thinking about polyethylene glycol, but I still think glycol does cause some problems in other equids.

Sadler: It was also shown in your *second moist* pet food, when they first entered the market a lot of propylene glycol was used. They have shown a lot of problems, at least with cats and dogs. So I would assume that it has got to be a high risk opportunity or high risk choice.

Blyde: Isn't ethylene glycol antifreeze?

Jessup: Are you saying propylene, or polyethylene or ethylene?

Blumer: Propylene is what they want to use, but polyethylene we know causes problems, that is what I was originally thinking about. But propylene is what they used in cattle for a long time, but they just break down with rumen flora; but a monogastrin can not do that.

Morkel: But a rhino is not a proper monogastrin. There is a far amount of fermentation in the foregut with rhinos.

R. Kock: How is that?

Morkel: Have you ever had to do a *necropsy* on a rhino? You can see it.

du Toit: I will meet you that there was probably experimentation going on with this polyethylene glycol in the 225.

Blumer: Polyethylene, that is antifreeze.

Dierenfeld: Propylene glycol is antifreeze, polyethylene...

227-230 MIXED INAUDIBLE COMMENTS

Citino: Antifreeze is just ethylene glycol, definitely not polyethylene.

Toit: Anyway, why I was commenting on this is that there is quite of bit of experimentation going on and apart from 232 discovering after the fact to some of the areas where the rhinos were. I have got a

sneaking suspicion something was also done in the bomas that I think.... Polyethylene glycol may have been given to some of the rhinos in the bomas at *Boldin*.

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